RESEARCH AND SCIENCE IN ALBERTA 1984-85

Alberta

ADVANCED EDUCATION
Research, Science and Planning

September 1986

ERRATA

Research and Science in Alberta 1984-85

Page xiv - first paragraph, last sentence should read:

..... Alberta's expenditure on research and development was 29 percent lower than of Canada (1.4 percent).

Page 31 - last paragraph, first sentence, should read:

The substantial increase in science expenditures by the Alberta Government over this six year period .....

ACKNOWLEDGEMENTS

Preparation of the final section of this year's report, "Overview of Research and Science Activities in Alberta," has been the joint effort of several government and university contributors. Research, Science and Planning wishes to acknowledge the assistance of: Dr. Alan Vanterpool, Assistant Deputy Minister and Mr. Robert Wilkes, Director, Advanced Manufacturing Technologies of the Department of Technology, Research and Telecommunications; Mr. Bob Armit, University of Alberta; Mr. Bob Martin, University of Calgary; Dr. Einard Haniuk, University of Lethbridge; and Dr. Michael Owen of Athabasca University.

As in past years, special thanks are extended to Karen Johnson, researcher and primary author of the report; Bert Plaus, Janet Thompson and Michel Boucher of Statistics Canada who provide many of the data; Linda Holmstrom for her work on the graphics; and Brenda Hedstrom who is responsible for putting the words into print.

Please forward any comments or questions regarding this report to:

Mr. Peter Hill
Director
Research, Science and Planning
Alberta Advanced Education
10th Floor, Devonian Building East
11160 Jasper Avenue
Edmonton, Alberta
T5K 0L1
(403)422-4845

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SYMBOLS

..	figures not available
--	nil or amount too small to be expressed
r	revised figures

NOTES

1. Totals may not be the sums of components due to rounding.

2. Figures cited for years prior to 1984-85 may reflect revision of previously published estimates.

3. The abbreviated form "social science" may be used to refer to both the social sciences and humanities.

PREFACE

This report describes the characteristics and magnitude of research and science expenditures in Alberta during the fiscal year 1984-85. An introductory section provides background information and outlines the organization of the report. Section I outlines research and development expenditures in Alberta by all funding and performing sectors, and examines areas of application and personnel components. Section II focuses on the Alberta Government's expenditures for both research and development and related scientific activities and draws comparisons with expenditures of other provincial governments. Section III provides an overview of specific research programs and facilities in the Province.

The data contained in this report were based primarily on an annual Statistics Canada survey of scientific activities of the Government of Alberta, various other statistical surveys conducted by Statistics Canada, and estimates produced by Research, Science and Planning of Alberta Advanced Education.

As this report is exploratory in nature and represents one of the few attempts at documenting all expenditures on research and science in Alberta, it should be used with caution. Due to limitations in the available data, these figures should be considered only as reasonable approximations.

SUMMARY

GRAPHIC SUMMARY

FIGURE 1

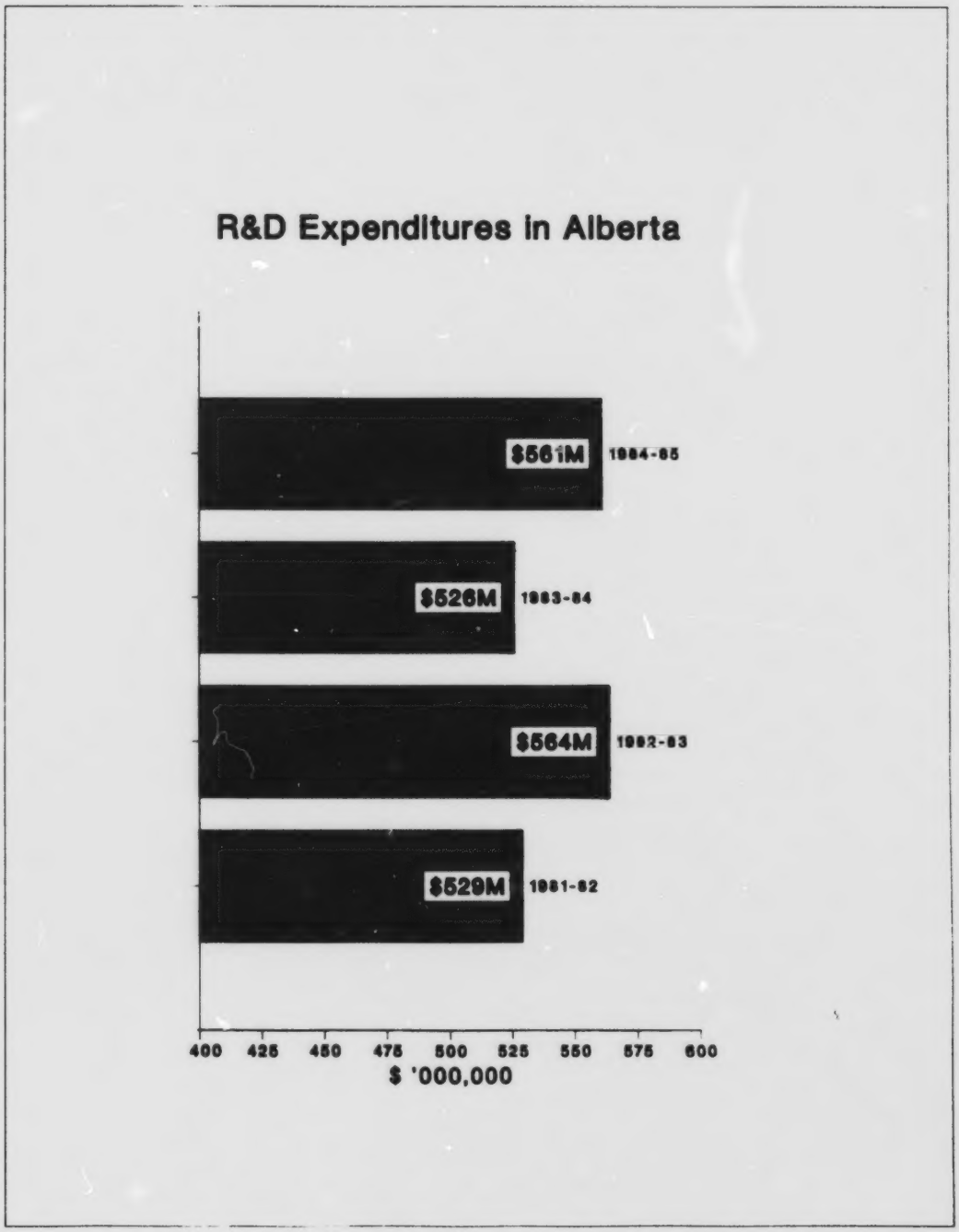

FIGURE ii

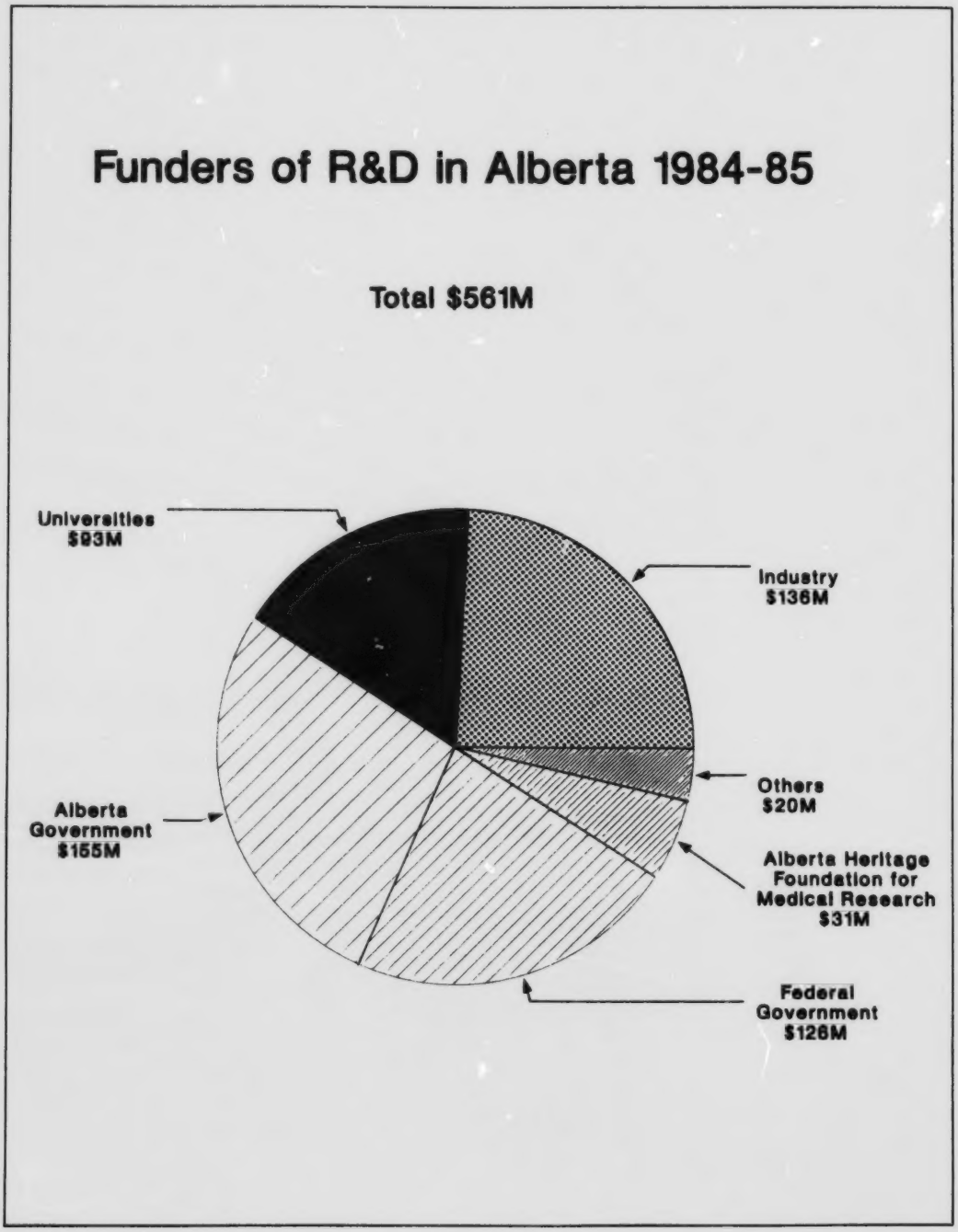
Funders of R&D in Alberta 1984-85
Total $561M
Universities $93M
Industry $136M
Others $20M
Alberta Heritage Foundation for Medical Research $31M
Federal Government $126M
Alberta Government $155M

FIGURE iii

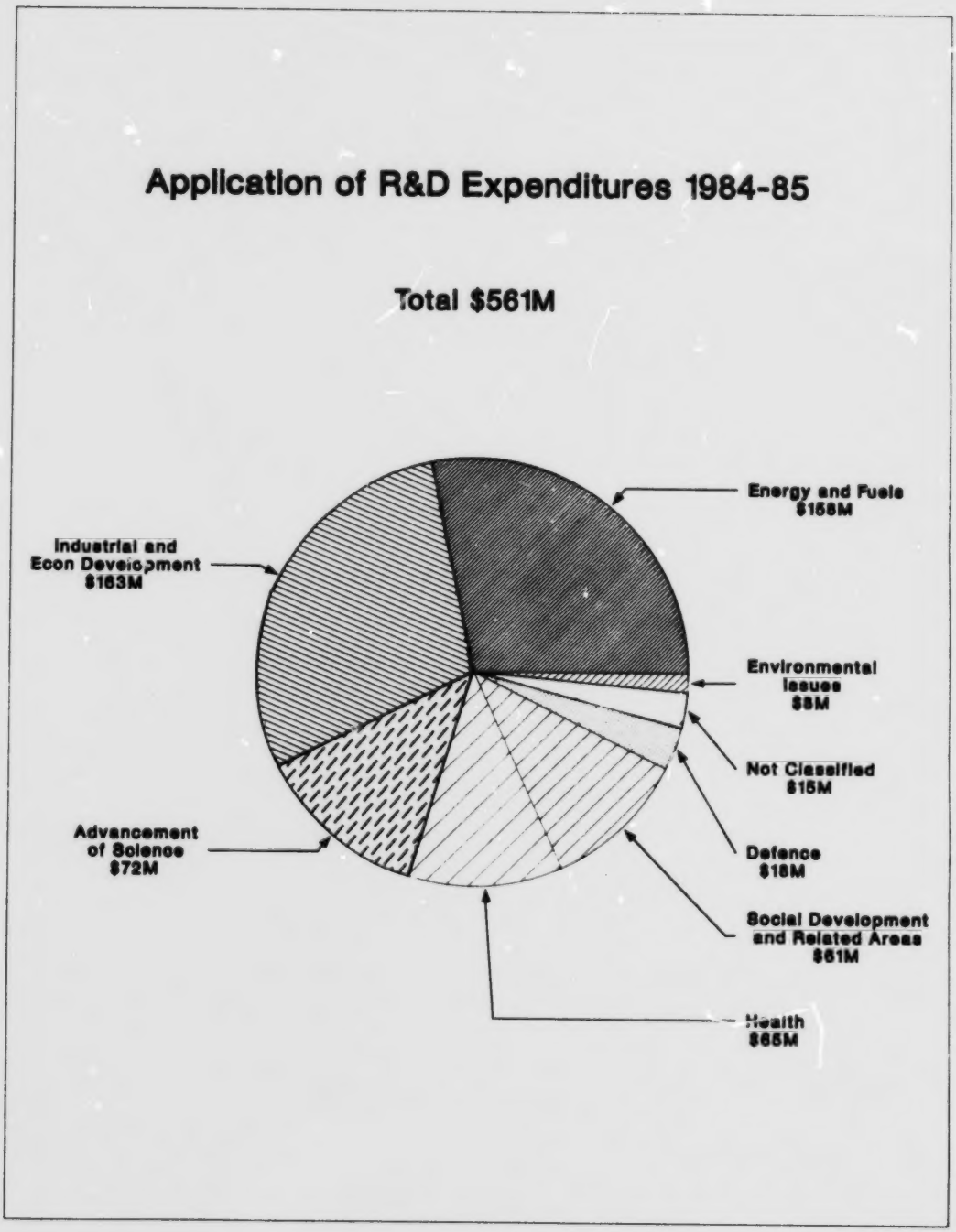
Application of R&D Expenditures 1984-85
Total $561M
Energy and Fuels
$168M
Industrial and
Econ Development
$163M
Environmental
Issues
$8M
Not Classified
$15M
Advancement
of Science
$72M
Defence
$18M
Social Development
and Related Areas
$61M
Health
$66M

FIGURE iv

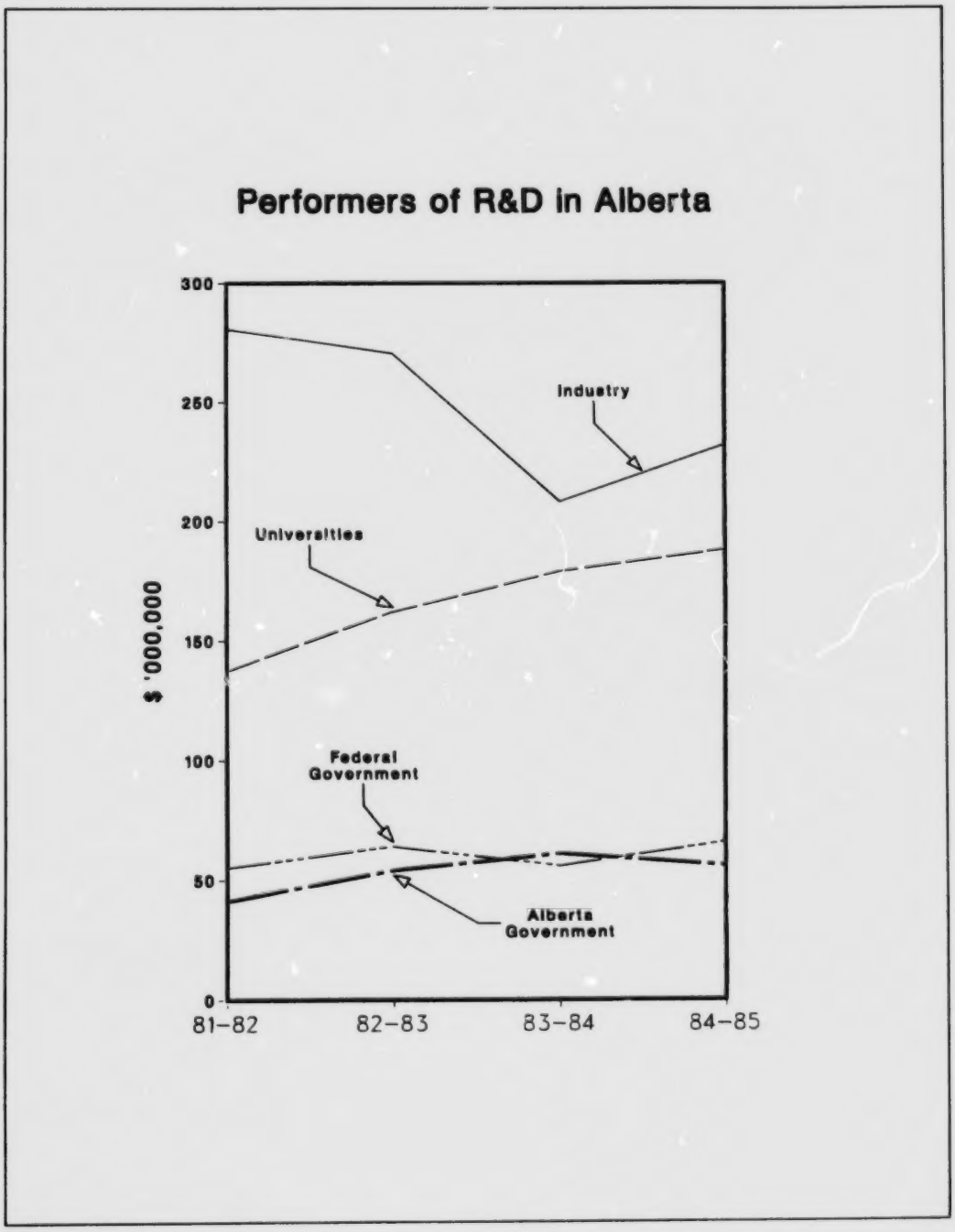
Performers of R&D in Alberta
$ '000,000
300
250
200
150
100
50
0
Industry
Univeralties
Federal Government
Alberta Government
81-82
82-83
83-84
84-85

TABLE 1

RESEARCH AND DEVELOPMENT INDICATORS

		Population[1] (Thousands)	GDP ($ Millions)	R&D ($ Millions)	R&D/Capita ($)	R&D/GDP (%)
Alberta	1981	2 237	49 037	529	236	1.08
	1982	2 319	52 838	564	243	1.07
	1983	2 347	54 812	526	224	0.96
	1984	2 342	57 458	561	240	0.98
Canada	1981	24 342	351 468	4 344	178	1.24
	1982	24 632	371 235	5 101	207	1.37
	1983	24 885	402 087	5 354	215	1.33
	1984	25 124	435 876	5 941	236	1.36

[1] As of June 1st.

ABSTRACT

1. **Total Research And Development Expenditures By All Sectors In The Province Were Approximately $561 Million During The Fiscal Year 1984-85 (Table 1).**

   This represents an increase of 7 percent over the $526 million spent in 1983-84, and accounts for approximately 9 percent of all research and development expenditures in Canada. On a per capita basis, research and development expenditures in Alberta ($240 per capita) were slightly higher than those for Canada as a whole ($236 per capita). As a proportion of Gross Domestic Product (1.0 percent), Alberta's expenditure on research and development was 40 percent lower than that of Canada (1.4 percent).

2. **The Alberta Government Funded 28 Percent ($155 Million) Of All Research And Development In Alberta and was the Primary Funder of Research in the Province (Table 2).**

   With an increase of 20 percent over 1983-84 expenditures, the Alberta Government expended more for research and development than any other provincial government surveyed. On a per capita basis, the Alberta Government funded research and development at approximately four times the level of any other provincial government.

3. **The Federal Government Funded 22 Percent ($126 Million) Of Research And Development In Alberta (Table 2).**

   This represents an increase of 18 percent over the $107 million spent in 1983-84, and accounts for approximately 6 percent of the Federal Government's total research and development expenditure in Canada. The Federal Government was a major contributor to sponsored research at Alberta universities.

4. **Industry Funded 24 Percent ($136 Million) Of Research And Development In Alberta (Table 2).**

   Industry was the second largest funder of research and development in the Province, although Alberta industry's share of support for research and development (24 percent) was below the Canadian average (39 percent).

5. **Alberta Universities, From Operating Funds, Supported 17 Percent ($93 Million) Of Research And Development In Alberta (Table 2).**

   This represented 17 percent of all expenditures by Canadian universities on research and development in Canada. In addition, sponsored research in the university sector has grown by 12 percent from $85 million in 1983-84 to $95 million in 1984-85.

6. **The Alberta Heritage Foundation for Medical Research (AHFMR) was the Single Largest External Sponsor of Research at Alberta Universities (Section 4.2).**

   With expenditures of approximately $31 million, the AHFMR accounted for one third of all sponsored research in Alberta universities.

7. **Industry Performed 41 Percent ($232 Million) Of The Total Dollar Value Of Research And Development Activities In Alberta (Table 4).**

   Industry was the primary performer of research and development in Alberta, showing an increase of 11 percent over 1983-84 expenditures. Alberta industry accounted for 8 percent of all industrial research in Canada. Activities were directed primarily toward oil and gas production and petroleum-based chemical research.

8. **Alberta Universities Performed 34 Percent ($188 Million) Of The Dollar Value Of Research And Development Activities In Alberta (Table 4).**

Approximately one half of the research performed by Alberta universities was sponsored by external organizations. Sixty-nine percent of the dollar value of research and development activities performed by Alberta universities was in the natural sciences, and 31 percent was in the social sciences. Alberta universities remain the primary performers of research and development in the social sciences and humanities.

9. **The Federal Government Performed 12 Percent ($66 Million) Of The Total Dollar Value Of Research And Development Activities In Alberta (Table 4).**

The Federal Government, through its research establishments located in Alberta, performed 52 percent of the research and development which it funded in the Province. This amounted to 5 percent of all research and development performed by the Federal Government in Canada.

10. **The Alberta Government, Including The Alberta Research Council, Performed 10 Percent ($56 Million) Of The Total Dollar Value Of Research And Development Activities In Alberta (Table 4).**

As a proportion of its total expenditure on research and development, the Government of Alberta performed 36 percent of the activities it funded in 1984-85. Expenditures by the Alberta Research Council increased 12 percent over 1983-84.

11. **Natural Sciences Research And Development Expenditures In Alberta Were Approximately $500 Million. Social Sciences and Humanities Research And Development Expenditures Were Approximately $61 Million (Table 1).**

Natural sciences research and development activity accounted for 89 percent of all research and development expenditures in Alberta, with the remaining 11 percent expended in social sciences research.

12. **Approximately 28 Percent ($158 Million) Of Research And Development Expenditures In Alberta Were Directed Toward The Area Of Energy and Fuels (Table 6).**

This is a lower level of energy research than in past years (compared with approximately 40 percent of research and development in 1982-83), and is accounted for primarily by decreased spending in the petroleum recovery industries. Proportionate increases were seen in the area of industrial and economic development, where growth occurred in the manufacturing and service industries.

13. **Excluding University Personnel, 1 708 Scientific And Professional Personnel As Well As 2 148 Technical And Other Support Personnel Were Employed In Research And Development Activity In Alberta (Table 7).**

Of scientific and professional personnel employed in Alberta, (excluding those employed by universities), 62 percent were employed in industry, 18 percent in Federal establishments, 11 percent in Alberta Government Departments and 9 percent with the Alberta Research Council.

14. **Total Expenditures On Scientific Activity By The Alberta Government Were $240 Million In 1984-85 (Table 9).**

Of total scientific activity expenditures, approximately $155million was directed toward research and development and $85 million was expended for related scientific activities. Expenditures for scientific activity increased 16 percent over the preceding fiscal year.

BACKGROUND AND TECHNICAL NOTES

1. INTRODUCTION

Research and science continue to play an increasingly important role in the economies of both Canada and the Province of Alberta. There is every indication that the future economic strength of the Province and the nation will be strongly influenced by the support of research and development by industry, universities, and government.

This report describes the characteristics and magnitude of scientific expenditures in Alberta. It outlines the research and development expenditures in Alberta by all who fund or support such activities. Particular attention is given to the support provided by the Government of Alberta.

The data upon which this report is based are difficult to compile in a consistent fashion. While the methods used in the preparation of this material have been improving, caution should be exercised in drawing comparisons with other similar data sources.

1.1 Background

Since 1973-74, an annual survey of the scientific activities of the Government of Alberta has been carried out by Statistics Canada (currently in cooperation with the Department of Advanced Education and the Alberta Bureau of Statistics). This survey provides the only continuing historical data base on the scientific activities of the Government of Alberta, and represents one of the few reliable data bases available to review the overall scientific activities of the Alberta Government. (The 1984-85 survey results are available on request from Research, Science and Planning of Alberta Advanced Education.)

In order to provide a comprehensive data base to aid in formulating policy decisions, the results of this survey have been placed in a broader comparative context. Research and Science in Alberta, 1984-85 offers an examination of the existing data relating to the scientific expenditures of the Federal Government, Alberta industry, Alberta universities, and other

provincial governments as well as the Government of Alberta. By comparing the contributions of each sector of the Alberta and Canadian economies, a clearer perspective of the total effort of research and science may emerge. There has been a growing recognition among all governments of the important place of research and development in an expanding economy. As a result, similar surveys of scientific activities are currently conducted by six provincial governments: British Columbia, Alberta, Manitoba, Saskatchewan, Ontario and New Brunswick.

1.2 Data Sources And Cautionary Notes

The data contained in this report are based on Statistics Canada surveys of scientific activities and on estimates produced by Research, Science and Planning of Alberta Advanced Education. Due to limitations in source information, these estimates should be considered only as reasonable approximations.

Information on scientific expenditures in Alberta has been collected, where possible, as reported by the funder. This approach is feasible when dealing with federal or provincial governments, as annual surveys of their science expenditures reflect payments to all performing sectors. For various reasons a performer may not identify the same funding as the agency providing the funding. Therefore, discrepancies arise when the performer's report is the only source of data for a given sector.

This is the case when accounting for expenditures by industry. The Statistics Canada publication, Industrial Research and Development Statistics, offers data from an annual survey of Canadian industry engaged in scientific activities. Since the publication summarizes expenditures by report of the performer, irreconcilable differences exist between these figures and those reported in similar data sources by survey of the funder. Therefore, caution should be exercised when comparing figures from various data sources.

Data on university expenditures are estimates produced by Research, Science and Planning of Alberta Advanced Education. These estimates are derived from annual financial statements of Alberta universities and from studies which

indicate that a fixed percentage of the operating expenditures of universities is attributable to research and development activity (Report of the Study on the Costs of University Research, Canadian Association of University Business Officers, 1982). Estimates of university expenditures on research and development present the greatest potential for error; however, no figures of a more precise nature currently exist. (A brief discussion of the methodology used in deriving these data is contained in Appendix B.)

All figures in this report, unless otherwise noted, refer to expenditures on research and development only. In order to estimate the extent of research and development activity in Alberta, foreign payments to industry for research performed in Alberta are included, but payments for research performed outside of the country are not. Capital expenditures on research and development are included for all sectors, with the exception of the university sector (See Appendix B). All figures are in current dollars.

1.3 Definitions

Scientific activities are defined as those scientific and technological activities which involve the generation, dissemination and initial application of new scientific and technological knowledge. These activities include both research and development activities and related scientific activities. Scientific activities are classified as belonging either to the natural sciences and engineering, or to the social sciences and humanities. (Detailed definitions of the terms used in this report are found in Appendix A.)

Research and development activities are defined as creative work undertaken on a systematic basis towards the acquisition and application of new scientific and technological knowledge.

Related scientific activities are defined as those activities which are supportive of research and development, but which do not include the acquisition of new knowledge. By convention, they include such activities as education support, statistical surveys, information services, special services and studies (systematic investigations carried out to provide information needed for planning or policy formulation), and the provision of museum services.

1.4 Outline

This report consists of three major sections. The first statistical section, 'Research and Development in Alberta', outlines expenditures for research and development in Alberta for the fiscal year 1984-85, identifies the major funders and performers of these activities, and describes research and development by area of application.

The second statistical section, 'Scientific Activities of the Government of Alberta', provides a more detailed view of the Alberta Government's expenditures. It includes information on both research and development activities and related scientific activities. Comparisons have been made with other provincial governments for which data are available.

Although a summary of science expenditure data is integral to policy formulation, a more comprehensive information base should include some description of the specific nature of research activity in the Province. The third section of the report, 'Overview of Research and Science Activities in Alberta', was prepared in order to provide a narrative account of the activities of various research funding and performing sectors in Alberta.

SECTION I
RESEARCH AND DEVELOPMENT IN ALBERTA: STATISTICS 1984-85

1. INTRODUCTION

This section describes the characteristics and magnitude of research and development expenditures in Alberta during the fiscal year 1984-85. It outlines the expenditures of the Alberta Government, the Federal Government, universities, industry, and 'others', and identifies the major performers of research and development. Areas of application have been identified, as have the personnel components of each sector.

2. RESEARCH AND DEVELOPMENT EXPENDITURES

In 1984-85, approximately $561 million was spent on research and development activities in Alberta. This represented an increase of 7 percent over 1983-84, and accounted for approximately 9 percent of all research and development expenditures in Canada (Table 1).

As an indication of how expenditures on research and development relate to the overall performance of the economy, it is possible to express research and development as a percentage of Gross Domestic Product (GDP). Research and development accounted for 1.0 percent of Alberta's GDP in 1984-85, the same proportion as in 1983-84. The comparable research and development expenditure in Canada was 1.4 percent of the nation's GDP (1.3 percent for 1983-84).[1]

However, it should be noted that differences in industrial structure between regions tend to distort this type of calculation. The greatest opportunity for research and development investment exists in the manufacturing sector. Alberta's largely resource-based economy puts the Province at an apparent disadvantage when GDP is employed as a measure of research and development intensity.

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[1] Alberta Advanced Education, Research, Science and Planning, estimates, July, 1986; Alberta Bureau of Statistics, Alberta Economic Accounts 1984.

Recognizing the limitations of the measure, the Organization for Economic Cooperation and Development[1] has recommended calculating these statistics on a per capita basis. When this procedure is applied to Alberta statistics, the Province fares more favourably: expenditures are either comparable with those elsewhere in Canada, or higher. In 1984-85 roughly $240 per capita were spent on research and development activities in Alberta, compared with $236 per capita in Canada. In 1983-84 about $224 per capita were spent on research and development in Alberta as compared with $215 per capita across Canada.[2]

2.1 Research and Development Expenditures in the Natural Sciences

In Alberta, research and development expenditures in the natural sciences were approximately $500 million in 1984-85, an increase of 6 percent over 1983-84. These expenditures represented roughly 89 percent of all research and development expenditures in Alberta, and 9 percent of all natural science research and development expenditures in Canada. Approximately $213 per capita were expended on natural science research and development activities in Alberta, while approximately $217 per capita were expended on natural science research and development activities in Canada.

2.2 Research and Development Expenditures in the Social Sciences and Humanities

In Alberta, research and development expenditures in the social sciences were approximately $61 million in 1984-85, an increase of $6 million or 10 percent over 1983-84. This represented roughly 11 percent of all research and development expenditures in Alberta, and 13 percent of all social science research and development expenditures in Canada. Approximately $26 per capita were expended on social science research and development activities in Alberta, while approximately $19 per capita were spent on social science research and development in Canada (Table 1).

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1 OECD Science and Technology Indicators: Resources Devoted to Research and Development, Paris, 1984, p.26.

2 Alberta Advanced Education, Research, Science and Planning, estimates, July, 1986; Alberta Bureau of Statistics, Alberta Economic Accounts 1984.

TABLE 1

RESEARCH AND DEVELOPMENT EXPENDITURES
IN ALBERTA 1983-84 AND 1984-85, AND CANADA 1984-85

Field of Science	$ Millions (%)					
	Alberta 1983-84(r)		Alberta 1984-85		Canada 1984-85	
Natural Sciences	471	(89)	500	(89)	5 460	(92)
Social Sciences	55	(11)	61	(11)	481	(8)
Total	526	(100)	561	(100)	5 941	(100)

Sources: Alberta Advanced Education, Research and Science in Alberta 1983-84; Alberta Advanced Education, Research, Science and Planning, estimates, July, 1986; Alberta Research Council, Annual Report 1985; Statistics Canada, Federal Scientific Establishments 1984-85; Statistics Canada, Scientific Activities of the Government of Alberta 1984-85 Survey Results; Statistics Canada, Science, Technology and Capital Stock Division, estimates, July, 1986; University of Alberta, Report of the Governors 1984-85; University of Calgary, Annual Report 1984-85; University of Lethbridge, Financial Statements 1984-85.

TABLE 2

RESEARCH AND DEVELOPMENT EXPENDITURES
BY SOURCE OF FUNDS IN ALBERTA 1983-84 AND 1984-85, AND CANADA 1984-85

Source of Funds	$ Millions (%)					
	Alberta 1983-84(r)		Alberta 1984-85		Canada 1984-85	
Provincial Government(s)	129	(24)	155	(28)	409	(7)
Federal Government	107	(20)	126	(22)	2 248	(38)
Industry	155	(29)	136	(24)	2 317	(39)
Universities	94	(18)	93	(17)	547	(9)
Others	42	(8)	51	(9)	420	(7)
Total	526	(100)	561	(100)	5 941	(100)

Sources: See Table 1.

3. SOURCES OF FUNDS

Alberta's research and development activities were funded by five sectors: the Provincial Government, the Federal Government, industry, universities, and 'others' (primarily private non-profit organizations and foreign sources). In 1984-85, the Provincial Government provided 28 percent of all research funds, industry 24 percent, the Federal Government 22 percent, universities 17 percent, and 'others' 9 percent. (The support by 'others' includes foreign funding of industrial research and development.) In Canada, industry funded approximately 39 percent of all research and development expenditures, the Federal Government 38 percent, universities 9 percent, provincial governments 7 percent, and 'others' 7 percent (Table 2).

3.1 Provincial Government

In 1984-85 the Alberta Government was the largest funder of research and development activities in the Province. The Alberta Government was the source of $155 million in research and development funds, accounting for 28 percent of total research and development expenditures in Alberta (Table 2).

The Alberta Heritage Foundation for Medical Research, funded from the proceeds of a $300 million endowment by the Provincial Government, is considered for the purposes of this analysis to be a private non-profit research organization. Thus its support of university research ($31 million[1] in 1984-85) is included under 'others'.

In 1984-85 the Government of Alberta expended more for research and development than did any other provincial government surveyed. In 1984-85, the Ontario Government's expenditures on research and development were roughly $119 million; the British Columbia Government's expenditures on research and development were $21 million; the Saskatchewan Government $18 million; the Manitoba Government $7 million; and the Government of New Brunswick

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1 This figure is as reported by offices of research services at Alberta universities.

TABLE 3

RESEARCH AND DEVELOPMENT EXPENDITURES OF SELECTED PROVINCIAL GOVERNMENTS AND THE FEDERAL GOVERNMENT 1984-85

Field of Science	Governments $ Millions (%)													
	Alberta		British Columbia		Saskatchewan		Manitoba		Ontario		New Brunswick[1]		Federal (in Canada)	
Natural Sciences	152	(98)	20	(97)	18	(96)	5	(72)	100	(84)	12	(..)	2 155	(96)
Social Sciences	3	(2)	1	(3)	1	(4)	2	(28)	19	(16)	..	(..)	93	(4)
Total	155	(100)	21	(100)	18	(100)	7	(100)	119	(100)	..	(..)	2 248	(100)

Notes: 1. The Government of New Brunswick collects data only in the natural sciences.

Sources: Statistics Canada, annual surveys of scientific activities of the respective provinces, 1984-85; Statistics Canada, Science, Technology and Capital Stock Division, estimates, July, 1986.

$12 million (Table 3). On a per capita basis, the Alberta Government spent approximately four times more on research and development than any other provincial government for which data were available.

3.2 Federal Government

In 1984-85, the Federal Government funded approximately $126 million of research and development in Alberta, up from $107 million in 1983-84.[1] This sector was the source of approximately 22 percent of all research and development expenditures in Alberta, compared with 38 percent of all research and development in Canada. Support of research in Alberta accounted for 6 percent of the Federal Government's total research and development expenditures in Canada (Table 2).

In 1984-85, the Federal Government's extramural expenditures on research and development in Alberta were approximately $60 million, excluding money transferred to the Province through the Alberta/Canada Energy Resources Research Fund. (Funds which were transferred to the Province under this agreement are reported as Provincial Government research and development expenditures.)

3.3 Industry

With expenditures of $136 million, Alberta industry was the second largest funder of research and development in the Province, accounting for 24 percent of research spending in Alberta. On the national level, Canadian industry accounted for 39 percent of research and development expenditures. As a proportion of all industry funded research in Canada, Alberta's private sector represented 6 percent (Table 2). (See Section 4.1 for further discussion of the recent pattern of expenditures in this sector).

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1 Federal tax incentives to the private sector are not considered direct funding for research and development, and are therefore not included in this summary.

3.4 Universities

In 1984-85, it is estimated that Alberta universities[1], through their operating budgets, funded approximately $93 million of research and development activities in Alberta, approximately the same figure as in 1983-84. This sector accounted for approximately 17 percent of all research and development expenditures in Alberta, and represented 17 percent of all expenditures by Canadian universities on research and development in Canada (Table 2). (These estimates do not include research supported by sources external to the universities, as these funds are recorded under the sector which provided the funds. See Appendix B for the methodology used to estimate university support for research and development activities.)

3.5 'Others'

'Other' organizations, primarily private non-profit organizations and foreign sources, funded approximately $51 million of research and development activities in Alberta in 1984-85. This sector accounted for approximately 9 percent of all expenditures on research and development in Alberta and approximately 12 percent of total expenditures by 'other' funders on research and development in Canada (Table 2).

Foreign funding of industrial research and development ($11 million) increased slightly from $10 million in 1983-84. The remaining funds reported as 'other' (approximately $40 million) were provided primarily by Alberta's private non-profit organizations for research and development performed by the university sector. The Alberta Heritage Foundation for Medical Research accounted for the largest expenditure by a private non-profit organization, providing $31 million[2] to Alberta universities for research and development activities.

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[1] Athabasca University has not been included in this analysis, as the methodology employed to estimate university research expenditures requires that the institutions show annual sponsored research receipts of greater than $1 million. See Section III for a description of recent research activities at Athabasca University.

[2] This figure is as reported by offices of research services at Alberta universities.

4. PERFORMERS

The two primary performers of research and development in Alberta were the industry and university sectors. Together these sectors accounted for 75 percent of the dollar value of research and development activities in Alberta. The Federal Government and Provincial Government Departments accounted, respectively, for 12 percent and 3 percent of all research and development performed in Alberta. The Alberta Research Council accounted for an additional 7 percent of expenditures for research and development activities in 1984-85 (Table 4).

4.1 Industry

In 1984-85, Alberta industry increased expenditures 11 percent over 1983-84, and showed some recovery from a decline in intramural research spending first observed in 1982-83. In 1984-85, industry accounted for $232 million or 41 percent of the total dollar value of research and development in Alberta, and remained the primary performer of research and development in the Province. Nationally, Canadian industry accounted for 48 percent of research spending (Table 4).

While resource based industries continued to show declines in research and development spending (decreasing 90 percent between 1981-82 and 1984-85), the manufacturing and service industries have contributed to the increase in private sector research activity observed in 1984-85. Between 1981-82 and 1984-85, manufacturing industries increased activity 229 percent, from $14 million to $46 million. The service industries showed an increase of 114 percent, from $22 million to $47 million over the same period.

Of the $232 million expended intramurally by industry, funds for 30 percent (approximately $69 million), were received from the Provincial Government and 9 percent (approximately $20 million) was received from the Federal Government, for a total of approximately $89 million. Foreign support for research and development performed by Alberta industry amounted to $11 million, accounting for 5 percent of industry's research and development funding.

TABLE 4

RESEARCH AND DEVELOPMENT EXPENDITURES BY PERFORMER
IN ALBERTA 1983-84 AND 1984-85, AND CANADA 1984-85

Performer	$ Millions (%)								
	Alberta 1983-84(r)			Alberta 1984-85			Canada 1984-85		
Provincial Government(s)									
Intramural	27		(5)	18		(3)	146		(2)
Research Council(s)	33		(6)	37		(7)	67		(1)
Subtotal		61	(12)		56	(10)		213	(4)
Federal Government		56	(11)		66	(12)		1 371	(23)
Industry		208	(40)		232	(41)		2 859	(48)
Universities		179	(34)		188	(34)		1 424	(24)
Others									
Hospitals and Health Organizations	17		(3)	15		(3)	..		..
Other	5		(1)	4		(1)	..		..
Subtotal		22	(4)		19	(3)		74	(1)
Total		526	(100)		561	(100)		5 941	(100)

Sources: See Table 1.

4.2 Universities

The second largest performer of research and development activities in Alberta in 1984-85 was the university sector. Universities performed approximately 34 percent or $188 million of research and development activities in Alberta, compared with the Canadian average for universities of 24 percent (Table 4).

Approximately 69 percent was in the natural sciences where, with expenditures of $129 million, Alberta universities performed approximately 26 percent of the dollar value of natural science research and development activities in the Province. The remaining 31 percent of research and development performed by Alberta universities was in the social sciences and humanities.

Universities are the primary performers of research and development in the social sciences and humanities. The $59 million in social science research performed by Alberta universities accounted for 97 percent of the total dollar value of social science research in Alberta. This particularly high contribution results partly from the fact that, although other sectors are active in scientific activities in the social sciences, little of their work can be classified as research and development. For example, in 1984-85 Provincial Government Departments performed $43 million of scientific activity in the area of social science, but of this only one million dollars was designated as research and development.

Approximately one half of the dollar value of the research and development performed by universities was sponsored or funded by external organizations. The balance was funded through university operating budgets. Approximately 9 percent of the total dollar value of research and development performed by the universities in the social sciences was sponsored by external organizations, compared to 70 percent sponsorship in the natural sciences.

The single largest external sponsor of research activities at Alberta universities is the Alberta Heritage Foundation for Medical Research, accounting for approximately one third of all sponsored research in 1984-85. Federal Government departments and research granting councils accounted for 42 percent; private non-profit organizations funded 10 percent; the Provincial Government 12 percent; and industry 3 percent.

4.3 Federal Government

In 1984-85, Federal Government scientific establishments located in Alberta expended $66 million, a 17 percent increase over 1983-84 expenditures. Research conducted by the Federal Government in Alberta accounted for 12 percent of all research and development in the Province. Nationally, Federal Government research and development accounted for 23 percent of research and development expenditures in Canada. Virtually all research performed by the Federal Government in Alberta was in the natural sciences (Table 4).

4.4 Provincial Government

The Provincial Government is considered primarily a funder rather than a performer of research and development, with intramural expenditures by Alberta Government Departments of $18 million in 1984-85. Compared with other provincial research organizations, the Alberta Research Council performs a substantial proportion of research and development: in 1984-85, the Alberta Research Council expended $37 million for research, an increase of 12 percent over 1983-84 expenditures. Together, Alberta Government Departments and the Alberta Research Council performed 10 percent of all research and development activities in Alberta.

Provincial Government Departments performed approximately 12 percent of the total dollar value of research and development activities funded by the Government of Alberta, and the Alberta Research Council performed another 24 percent. Other provincial governments performed proportionately more of the research they funded, and the provincial research organizations proportionately less. The Alberta Government directed more research funds to hospitals and health organizations than did other provincial governments (Table 5).

TABLE 5

PROVINCIAL GOVERNMENT RESEARCH AND DEVELOPMENT EXPENDITURES BY PERFORMER 1984-85

Performer	Governments $ Thousands (%)					
	Alberta	British Columbia	Saskatchewan	Manitoba	Ontario	New Brunswick[1]
Intramural	18 277 (12)	11 438 (55)	3 260 (18)	2 346 (34)	58 576 (49)	1 051 (9)
Provincial Research Organization	37 297 (24)	594 (3)	4 315 (24)	377 (5)	4 245 (4)	831 (7)
Hospitals and Health Organizations	15 244 (10)	162 (1)	886 (5)	-- (--)	11 033 (9)	-- (--)
Industry	68 697 (44)	2 024 (10)	3 604 (20)	460 (7)	11 660 (10)	8 966 (74)
Universities	11 770 (8)	5 303 (25)	5 796 (32)	3 155 (45)	30 509 (26)	452 (4)
Others	3 814 (3)	1 288 (6)	407 (2)	644 (9)	2 576 (2)	738 (6)
Total	155 099 (100)	20 809 (100)	18 268 (100)	6 982 (100)	118 599 (100)	12 038 (100)

Notes: 1. The Government of New Brunswick collects data only in the natural sciences.

Source: Statistics Canada annual surveys of scientific activities of the respective provinces 1984-85.

5. APPLICATION

Data collected on Provincial Government expenditures by area of application are fairly reliable from year to year. However, techniques used in combining this information with information on application of expenditures in other sectors (industry, the Federal Government, and the universities) lack precision. For this reason caution should be exercised when interpreting these figures.

The primary performers of research and development are identified for each application area; however, no attempt has been made to categorize expenditures by funding source. Although sectors may have a strong focus in the performance of research and development (such as industry's role in energy and fuels research), it should be remembered that funding is often received from several agencies. Because the Government of Alberta can be considered primarily a funder rather than a performer of research, its support role in many areas of application may be overlooked. In 1984-85, the Provincial Government was the source of 28 percent of all research and development expenditures in the Province. (Refer to Table 11 for a summary of total science expenditures of the Government of Alberta by area of application.)

Research and development expenditures have been broken into eight areas of application: advancement of science, defence, energy and fuels, environmental issues, health, industrial and economic development, social development and related areas, and transportation and communications (Table 6).

5.1 Advancement of Science

It is estimated that approximately $72 million was spent on research and development related to the general advancement of science. This represented roughly 13 percent of all research and development expenditures in Alberta. With the exception of approximately $1 million of research performed by the Alberta Research Council, this figure largely reflects the activities of Alberta's universities (Table 6).

The classification of research and development activities under this heading, in particular, involves problems of definition. This area involves research done for the general advancement of science and refers to basic rather than applied research. With the exception of the activities of a few faculties (such as Agriculture and Forestry, or Medicine, where area of application is reasonably clear), it is often difficult to classify the research activities of the universities. In recognition of the major role played by the universities in augmenting existing knowledge in all fields, much of their research activity was identified as serving the advancement of science.

5.2 Defence

Approximately $18 million was spent on activities related to defence, representing 3 percent of total research and development expenditures. Only the Federal Government reported expenditures in this application area (Table 6).

5.3 Energy and Fuels

Approximately $158 million was spent on research and development activities in the area of energy and fuels in 1984-85, representing 28 percent of all research and development expenditures in Alberta. The major performer of research and development activities in energy and fuels was industry, accounting for 78 percent of expenditures in this area of application. The Provincial Government performed 3 percent, the Federal Government 10 percent, and the Alberta Research Council 8 percent (Table 6).

Energy and fuels includes the sub-fields of fossil fuels, hydro-electric energy, and nuclear energy. It appears that most of the expenditures in this area were related to fossil fuels.

5.4 Environmental Issues

An estimated $8 million was spent on research and development activities related to environmental issues. The Alberta Research Council was the primary performer, accounting for approximately 60 percent of expenditures, while Alberta Government Departments accounted for 40 percent (Table 6).

TABLE 6

APPLICATION OF RESEARCH AND DEVELOPMENT EXPENDITURES IN ALBERTA 1983-84 AND 1984-85

Area of Application	$ Millions (%)			
	1983-84(r)		1984-85	
Advancement of Science	71	(13)	72	(13)
Defence	15	(3)	18	(3)
Energy and Fuels	164	(31)	158	(28)
Environmental Issues	7	(1)	8	(1)
Health	65	(12)	65	(12)
Industrial and Economic Development:				
Agriculture	42	(8)	48	(9)
Other	98	(19)	114	(20)
Subtotal	140	(27)	163	(29)
Social Development and Related Areas	56	(11)	61	(11)
Transportation and Communications[1]	..	(..)	..	(..)
Not Classified[2]	9	(2)	15	(3)
Total	526	(100)	561	(100)

Notes: 1. Disaggregated data for industrial research and development in this category are not available from Statistics Canada. Industrial communications research in the Province is reported in the broader category of industrial and economic development.

2. In order to comply with the secrecy section of the Statistics Act, industry may not list expenditures for certain industry groupings. For this reason some private sector expenditures can not be grouped by application area.

Source: Alberta Advanced Education, Research, Science and Planning, estimates, July, 1986.

The area of environmental issues includes research activities intended to preserve or restore environmental quality, including work on pollution, but excluding related medical research.

5.5 Health

It is estimated that approximately $65 million was spent on health-related research and development activities in Alberta in 1984-85. This represented roughly 12 percent of all research and development expenditures in Alberta. Universities accounted for 74 percent of health related research and development and hospitals and health organizations 24 percent (Table 6).

The area of health involves activities related to the maintenance and improvement of the physical well-being of the population. Included are research activities in medicine, dentistry, pharmacy, nursing and rehabilitation medicine.

5.6 Industrial and Economic Development

It is estimated that approximately $163 million was spent on research and development activities in the area of industrial and economic development, representing roughly 29 percent of all research and development expenditures in Alberta in 1984-85. The private sector accounted for 57 percent of research and development in this application area, with expenditures of $46 million in manufacturing and $47 million in the service industries. The Federal Government performed the second largest share of research in this area (20 percent) in its research establishments throughout the Province. The Alberta Research Council accounted for 11 percent, the university sector 6 percent, and the Provincial Government Departments 4 percent (Table 6).

Industrial and economic development includes research activities related to agriculture, fisheries, forestry, manufacturing and minerals. In 1984-85, $48 million was directed towards research and development related to agriculture. The Federal Government was the primary performer in this area with approximately $32 million expended on agricultural research and development, while the Provincial Government, including the Alberta Research Council, expended $9 million.

5.7 Social Development and Related Areas

It is estimated that approximately $61 million was spent on research and development activities in the area of social development, representing 11 percent of all research and development in Alberta. Universities accounted for essentially all research expenditures in this area, with the exception of $2 million expended by the Provincial Government (Table 6).

This area of application includes the sub-fields of culture, sport, recreation, education, human resources, and urban and regional studies.

6. PERSONNEL[1]

Only recently have consistent figures on the personnel component of research and development activities become available. However, data gathering remains hindered by significant technical and conceptual problems, making accurate assessments difficult.

For comparative purposes, the unit of 'person-year' is used to indicate a full-time equivalent staff position engaged directly in research and development. This allows an individual's time to be apportioned to different activity categories where that person is engaged in a variety of tasks, only some related to research and development.

Individuals engaged in research and development are classified either as 'professional and scientific personnel' or as 'technical and other support personnel'. (See Appendix A for definitions.)

6.1 Total Employment in Research and Development

The equivalent of 1 708 full-time persons were employed in a scientific or professional capacity engaged in research and development activities in the Province, not including the equivalent of 1 700 persons engaged in research in Alberta's universities. The equivalent of an additional 2 148 persons, excluding those at Alberta universities, were engaged on a full-time basis in a technical or other support capacity in an occupation related to research and development (Table 7).

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1 Figures in this section indicate full-time equivalents or 'person-years'. Because each individual may be engaged in a variety of tasks apart from those directly related to research and development, the actual number of people who were employed in an occupation related to research and development would be several times greater than the figures quoted here.

TABLE 7

PERSONNEL ENGAGED IN INTRAMURAL RESEARCH AND DEVELOPMENT
IN ALBERTA AND CANADA 1984-85
(PERSON-YEARS)

Sector and Field Of Employment	Scientific And Professional		Technical and Other Support		Total	
	Alberta	Canada	Alberta	Canada	Alberta	Canada
Provincial Government						
Natural Sciences	154	930	213	1 490	367	2 420
Social Sciences	36	520	3	410	39	930
Total	190	1 450	216	1 900	406	3 350
Provincial Research Organization(s)	161	435	190	563	351	998
Federal Government						
Natural Sciences	302	..	717	..	1 019	..
Social Sciences	--	..	--	..	--	..
Total	302	5 736	717	11 836	1 019	17 572
Industry	1 055	18 790	1 025	19 100	2 080	37 890

Sources: Statistics Canada, Federal Scientific Establishments, 1984-85; Statistics Canada, "The Provincial Research Organizations 1984", Science Statistics, Vol. 9, #11; Statistics Canada, Scientific Activities of the Government of Alberta 1984-85 Survey Results; Statistics Canada, Science, Technology and Capital Stock Division, estimates, July, 1986.

6.2 Provincial Government

The Alberta Government employed the equivalent of 190 scientific and professional persons during 1984-85, 154 of whom were engaged in natural science research. In addition, 161 scientific and professional persons were employed by the Alberta Research Council. The Provincial Government also employed the equivalent of 216 technical and other support persons, while the Alberta Research Council employed approximately 190 persons (Table 7).

The Alberta Government spent approximately $95 000 per professional researcher from its intramural research and development funds, compared with an average expenditure of $101 000 for provincial governments across Canada (Table 8).

6.3 Federal Government

In its research establishments located in Alberta, the Federal Government employed 302 scientific and professional persons or 5 percent of those employed in federal research establishments across Canada. Essentially all of these persons were engaged in natural science research and development. An additional 717 persons were employed in technical or support capacities (Table 7).

In 1984-85, the Federal Government spent $219 000 per professional research person in its Alberta establishments. Nationally, the Federal Government spent $239 000 on each of its professional research staff across Canada (Table 8).

6.4 Industry

Industry in Alberta employed 1 055 full-time equivalent scientific and professional personnel during 1984-85, about 6 percent of the total across Canada. An additional 1 025 persons were employed in technical or support capacities (Table 7).

In 1984-85, Alberta industry spent $220 000 per professional research person, considerably greater than the Canadian average for industry of $152 000 (Table 8).

TABLE 8

INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES
PER SCIENTIFIC AND PROFESSIONAL PERSON
ALBERTA AND CANADA 1984-85

	Provincial Government	Provincial Research Organization(s)	Federal Government	Industry
Alberta:				
Intramural R&D Expenditure ($ Millions)	18	37	66	232
Scientific and Professional Personnel (Person - Years)	190	161	302	1 055
Expenditure/Professional Person ($ Thousands)	**95**	**230**	**219**	**220**
Canada:				
Intramural R&D Expenditure ($ Millions)	146	67	1 371	2 859
Scientific and Professional Personnel (Person - Years)	1 450	435	5 736	18 790
Expenditure/Professional Person ($ Thousands)	**101**	**154**	**239**	**152**

Sources: Statistics Canada, Federal Scientific Establishments, 1984-85; Statistics Canada, Scientific Activities of the Government of Alberta 1984-85 Survey Results; Statistics Canada, Science, Technology and Capital Stock Division, estimates, July, 1986.

6.5 Universities

In theory, each of the 4 800 academic staff members in Alberta's universities is a scientific or professional person directly engaged in research activities. However, the instructional and community service obligations of faculty members restrict the amount of time which may be committed to research activities. The full-time equivalent figure for staff engaged solely in research activities is estimated to be approximately 1 700 person-years for the three major Alberta universities.

SECTION II
SCIENTIFIC ACTIVITIES OF THE GOVERNMENT OF ALBERTA: STATISTICS 1984-85

1. INTRODUCTION

This section summarizes the major findings of the report, Scientific Activities of the Government of Alberta, 1984-85 Survey Results, available on request from Research, Science and Planning of Alberta Advanced Education. This section also provides comparative data on the 1984-85 expenditures of the Provincial Governments of Ontario, British Columbia, Saskatchewan, Manitoba and New Brunswick. (Historic data will not be presented for the latter two provinces, as they have only recently initiated science surveys.)

Scientific activities are those activities which involve the generation, dissemination and initial application of new scientific knowledge and technology. Included are both research and development activities and related scientific activities. Related scientific activities are activities ancillary to research and development, which do not include the acquisition of new knowledge. They do include such activities as scientific data collection, feasibility studies, operations and policy studies, and educational support. Only the Federal Government and selected provincial governments collect expenditure data on related scientific activities.

2. TRENDS

Between 1978-79 and 1984-85, expenditures by the Government of Alberta for scientific activity increased 191 percent. The Saskatchewan Government increased expenditures 120 percent over the same period, the British Columbia Government 51 percent, and the Ontario Government 51 percent (see Figure 1).

The substantial increase in science expenditures by the Alberta Government over this seven year period is attributable to increased support by a number of departments. In 1984-85, Alberta Hospitals and Medical Care expended $20 million for scientific activity, an increase of 257 percent over its 1978-79 expenditure; Alberta Energy and Natural Resources expended $20 million, a 115 percent increase; and Alberta Agriculture expended $19 million, an increase of 451 percent. Alberta Culture has demonstrated a considerable increase in scientific activity, with an expenditure of $27 million in 1984-85, more than 10 times the Department's 1978-79 expenditure.

FIGURE 1

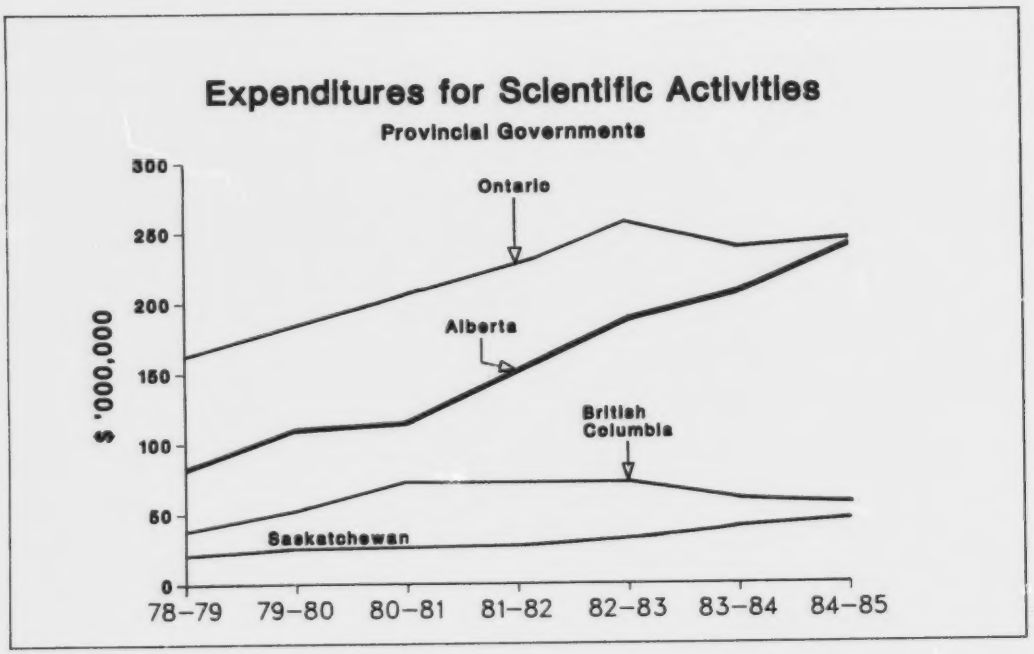
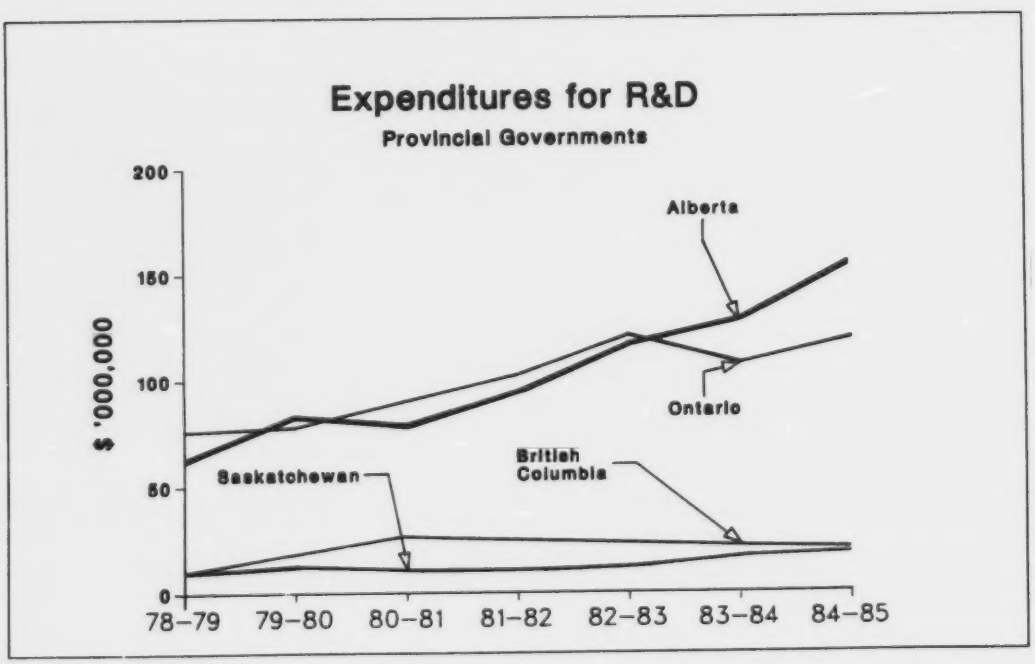


FIGURE 2



Research and development have accounted for the majority of the Alberta Government's science expenditures over the past seven years. Figure 2 provides an interprovincial comparison of research and development expenditures and reveals that the Governments of Ontario and Alberta have consistently led the other provinces surveyed in their support of research and development. By 1983-84 the Alberta Government was expending more for research and development than any other provincial government surveyed.

3. CHARACTERISTICS OF EXPENDITURES

A detailed description of the Alberta Government's expenditures on scientific activities for the year 1984-85 can be found in the report, Scientific Activities of the Government of Alberta, 1984-85 Survey Results. The following discussion highlights some of the important characteristics of these expenditures and draws comparisons with other provincial governments (Table 9).

Table 9 indicates that the Alberta Government's science expenditures show a somewhat different distribution from expenditures by other governments surveyed. Comparatively more funds are directed toward activities in the natural sciences, with the majority of expenditures supporting research and development. In 1984-85, 78 percent ($188 million of the Alberta Government's science expenditure) supported natural science activities, and of this, 81 percent ($152 million) was devoted to research and development.

This relatively high proportion of research and development in the natural sciences is maintained primarily by three departments or agencies. The Alberta Oil Sands Technology and Research Authority accounted for approximately 51 percent ($77 million) of current expenditures for natural science research and development in 1984-85; expenditures by the Department of Hospitals and Medical Care ($18 million) accounted for 12 percent; and the Executive Council's payments to the Alberta Research Council ($21 million) accounted for an additional 14 percent.

TABLE 9

EXPENDITURES ON SCIENTIFIC ACTIVITIES OF SELECTED PROVINCIAL GOVERNMENTS 1984-85

Type of Scientific Activities	Governments $ Millions (%)											
	Alberta		British Columbia		Saskatchewan		Manitoba		Ontario		New Brunswick[1]	
Natural Sciences												
Research and Development	152	(81)	20	(46)	18	(60)	5	(21)	100	(61)	12	(51)
Related Scientific Activities	36	(19)	23	(54)	12	(40)	19	(79)	64	(39)	12	(49)
Total Scientific Activities	188	(78)	44	(76)	29	(64)	24	(73)	164	(67)	24	(..)
Social Sciences												
Research and Development	3	(5)	1	(5)	1	(4)	2	(22)	19	(23)	..	
Related Scientific Activities	49	(95)	13	(95)	16	(96)	7	(78)	62	(77)	..	
Total Scientific Activities	52	(22)	14	(24)	17	(36)	9	(27)	81	(33)	..	
Total												
Research and Development	155	(65)	21	(36)	18	(40)	7	(21)	119	(48)	..	
Related Scientific Activities	85	(35)	37	(64)	28	(60)	26	(79)	126	(52)	..	
Total Scientific Activities	240	(100)	57	(100)	46	(100)	33	(100)	245	(100)	..	

Notes: 1. The Government of New Brunswick collects data only in the natural sciences.

Sources: Statistics Canada, annual surveys of scientific activities of participating provinces, 1984-85.

TABLE 10

EXPENDITURES ON SCIENTIFIC ACTIVITIES OF
SELECTED PROVINCIAL GOVERNMENTS BY PERFORMER 1984-85

Performer	Governments $ Millions (%)											
	Alberta		British Columbia		Saskatchewan		Manitoba		Ontario		New Brunswick[1]	
Intramural	88	(37)	42	(73)	24	(52)	24	(75)	149	(61)	10	(42)
Provincial Research Organization	39	(16)	1	(2)	4	(10)	--	(--)	4	(2)	1	(5)
Hospitals and Health Organizations	15	(6)	--	(--)	1	(2)	--	(--)	12	(5)	1	(2)
Industry	78	(33)	6	(10)	8	(17)	2	(7)	32	(13)	10	(43)
Universities	13	(5)	6	(10)	7	(15)	4	(11)	39	(16)	1	(2)
Others	6	(3)	2	(4)	2	(4)	2	(6)	9	(4)	1	(6)
Total	240	(100)	57	(100)	46	(100)	33	(100)	245	(100)	24	(100)

Notes: 1. The Government of New Brunswick collects data only in the natural sciences.

Sources: Statistics Canada, annual surveys of scientific activities of participating provinces, 1984-85.

4. PERFORMERS

Compared with other provincial governments, the Alberta Government performs a relatively small proportion (37 percent) of the scientific activities it funds. Conversely, it expends a greater proportion (16 percent) in support of its provincial research organization: in 1984-85, the Alberta Research Council received $39 million in Provincial Government grants and contracts. Industry was the primary external performer, receiving $78 million (33 percent of the Alberta Government's science expenditure) in 1984-85 (Table 10).

The Alberta Oil Sands Technology and Research Authority was the primary contributor to the industrial sector in 1984-85. Together with the Departments of Agriculture and Hospitals and Medical Care, AOSTRA was also a major contributor to the university sector. Science expenditures in hospitals and health organizations were accounted for almost exclusively by the Department of Hospitals and Medical Care.

While the Alberta Government conducts most of its own related scientific activities, only 12 percent of the research and development it funds is performed in-house. Alberta Agriculture, Alberta Environment, the Environmental Centre, and the Department of Energy and Natural Resources were major performers of research and development in 1984-85.

5. APPLICATION

Compared with other provincial governments, the Alberta Government supports a greater share of scientific activities in the area of energy and fuels ($81 million or 34 percent of 1984-85 science expenditures). In 1984-85, activities related to industrial and economic development accounted for $52 million or 22 percent of science expenditures. Approximately 45 percent of the support for industrial and economic development was directed toward activities related to agriculture (Table 11).

TABLE 11

EXPENDITURES ON SCIENTIFIC ACTIVITIES OF SELECTED PROVINCIAL GOVERNMENTS BY APPLICATION 1984-85

Application	Governments $ Millions (%)											
	Alberta		British Columbia[1]		Saskatchewan		Manitoba		Ontario		New Brunswick[2]	
Advancement of Science	10	(4)	--	(1)	1	(3)	2	(5)	13	(5)	1	(3)
Energy and Fuels	81	(34)	1	(2)	5	(10)	6	(18)	21	(8)	3	(13)
Environmental Issues	21	(9)	8	(18)	3	(6)	4	(12)	34	(14)	1	(5)
Health	27	(11)	4	(9)	10	(21)	3	(9)	45	(18)	--	(1)
Industrial and Economic Development	52	(22)	21	(48)	13	(28)	10	(30)	89	(36)	17	(71)
Social Development and Related Areas	45	(19)	2	(4)	10	(21)	7	(23)	33	(13)	1	(4)
Transportation and Communications	4	(2)	1	(3)	2	(4)	1	(2)	8	(3)	--	(--)
Total[3]	240	(100)	44	(100)	46	(100)	33	(100)	245	(100)	24	(100)

Notes:
1. The Government of British Columbia collects data by area of application only in the natural sciences.
2. The Government of New Brunswick collects data only in the natural sciences.
3. Totals may not equal the sum of components due to exclusion of expenditures categorized as "other."

Sources: Statistics Canada, annual surveys of scientific activities of participating provinces, 1984-85.

SECTION III
OVERVIEW OF RESEARCH AND SCIENCE ACTIVITIES IN ALBERTA

1. INTRODUCTION[1]

Research and development involves significant transfers of resources between units, organizations and sectors, especially between governments and other performers. The statistical sections of this report have portrayed the exchange of funds at the sectoral level. However, since the data are restricted to aggregated figures, it is difficult to present a complete picture of the contributions of individual organizations.

The last section of the report, therefore, provides an overview of specific activities of various research units and organizations in the Province. **It is not an exhaustive listing of research funding and performing bodies in Alberta, but should be a representative survey of ongoing research activity.** Hopefully, this additional information will afford the reader a clearer understanding of the intricate network of research support that has evolved in the Province over the past few years.

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[1] Assistance with portions of Section III has been provided by Alberta Technology, Research and Telecommunications, and by the offices of research services at the Universities of Alberta, Calgary, Lethbridge and Athabasca. See also, New Frontiers: Technology Development and Applied Research in Alberta.

2. GOVERNMENT OF ALBERTA

There are two aspects to the involvement of the Alberta Government in research and science. The first is the provision of programs in support of research in other performing sectors (extramural activity). The second is the ongoing activity of its departments and agencies whose mandates include research (intramural activity).

In the spring of 1986, the Alberta Government also created a new department with a particular commitment to research and technology, Alberta Technology, Research and Telecommunications. The focus of the Department is on advanced technologies and on information and communications as means to promote Alberta as a centre for research on, and commercial application of, new technologies.

2.1 Extramural Support

Through various programs and agencies, the Alberta Government provides research support to universities, private industry, or to qualified individuals. Research assistance is available through:

Alberta Oil Sands Technology and Research Authority (AOSTRA). Established in 1975, AOSTRA is funded through the Alberta Heritage Savings Trust Fund and provides financial support to private firms and research institutions. Objectives are to develop economically viable and environmentally acceptable petroleum technology in areas related to oil sands, heavy oil and enhanced recovery of conventional oil. Research projects consist primarily of field projects with industry that are handled on a shared cost or cost recovery basis.

Alberta/Canada Energy Resources Research Fund (A/CERRF). As a result of the 1974 oil pricing agreement between the Federal Government and the producing provinces, the Federal Government committed $96 million to Alberta in support of energy-related research. The fund supports research in the areas of: coal; conventional energy resources; energy conservation and renewable energy; and related capital projects.

Alberta Heritage Foundation for Medical Research (AHFMR). The AHFMR was created in 1979 to establish and support a balanced long-term program of medical research based in Alberta. Using the interest revenue generated from a $300 million endowment from the Alberta Heritage Savings Trust Fund, the Foundation supports researchers in the basic medical and clinical sciences, as well as in a broad spectrum of medical related disciplines.

Farming for the Future. An agricultural research program financed through the Alberta Heritage Savings Trust Fund, Farming for the Future was established to support the advancement of agricultural technology by initiating or augmenting research efforts by private industry, universities and government agencies.

Alberta Foundation for Nursing Research. The Foundation was established in 1982 to administer funds over five years to help nurses undertake research for the purpose of improving nursing practice.

Applied Cancer Research Fund. Established in 1977, this program will run until March, 1987 to provide funds for facilities, equipment, and operating expenses associated with applied research at specialized cancer referral centres.

Occupational Health and Safety Heritage Grant Program. This program was established in 1981 to support research and education designed to prevent accidents and ill health resulting from employment, and to promote the health of Alberta workers through improved working conditions.

2.2 Intramural Activities

In addition to its support of research activity in other performing sectors, the Alberta Government conducts research in its own labs and research facilities:

The Alberta Research Council (ARC). Located in Edmonton, with offices in Calgary, Devon, Red Deer, Nisku and Lethbridge, the ARC is Canada's oldest and largest provincial research organization. Support is provided to industry and government through a broad range of research with applications in energy, agriculture, forestry, environment and natural resources. Emphasis is placed on industrial assistance, and on the development of new technologies.

Alberta Agriculture. In-house research facilities of the Department of Agriculture include:

Food Processing Development Centre. This new facility in Leduc provides assistance to Alberta food processors in order to increase their ability to meet the needs of the marketplace through new technologies and the development of new products and processes.

Alberta Horticultural Research Centre (AHRC). Located in Brooks, the AHRC works collaboratively with Alberta universities and Agriculture Canada on projects relating to all areas of horticulture and irrigated specialty crops.

Regional Crops Laboratories. These laboratories, located at Brooks, Fairview and Olds, provide diagnostic and extension services in plant diseases, insects and weeds. The laboratories work closely with the Alberta Environmental Centre in Vegreville.

O.S. Longman Building. Laboratories at this Edmonton facility are involved in soil and feed testing, food analyses and consulting services, veterinary pathology, and animal toxicology.

Other facilities and programs. In Lethbridge, Alberta Agriculture carries out research in the area of irrigation systems, water use efficiency and other aspects of irrigation management, and is involved in weather modification research in cooperation with the Alberta Research Council. The department operates the Field Unit at Lacombe and veterinary laboratories at Airdrie, Edmonton, Fairview and Lethbridge.

Alberta Environment. The Research Management Division of Alberta Environment is responsible for coordinating and administering research pertinent to departmental needs on environmental matters, including the identification and implementation of long-term environmental research programs. Over the past few years the department has been involved in projects addressing a diverse range of environmental issues, including the study of acid forming emissions,

reclamation research, waste management, and the identification of environmental contaminants.

Alberta Environmental Centre. Situated in Vegreville, the Centre is responsible for studying environmental problems identified by Provincial Government departments and agencies and public health units. A multidisciplinary staff specializes in applied research and development and the provision of analytical and laboratory services.

Program areas include: analytical, diagnostic, extension and technical services; pest management; water/wastewater; environmental toxicology; living natural resources; waste management; and land resources management.

Energy and Natural Resources.[1] Five units of Alberta Energy and Natural Resources report responsibilities in the area of research and science.

> Public Lands. This division conducts field investigations and inventories in order to examine such areas as soil characteristics, physical features and natural flora. The division also provides the public with technical support in the area of range management.
>
> Fish and Wildlife. This division conducts research into ecological and physiological variables affecting Alberta's fish and wildlife populations. The division has also been involved in the development of various methodologies of collecting, analyzing, or mapping data in order to describe the fish and wildlife resources of the Province.

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[1] Information on Alberta Government research activities was collected in part from science survey questionnaires completed for the 1984-85 fiscal year. Alberta Energy and Natural Resources has since been reorganized to create two new departments, Alberta Forestry, Lands and Wildlife, and Alberta Energy.

Resource Evaluation and Planning. The branch conducts technical surveys for evaluation of environmental parameters, including soils, vegetation, forest productivity, ecological relationships and climate.

Alberta Forest Service (AFS). The AFS conducts in-house research in the area of forest land management and provides research support to the Alberta forest products industry through its Forest Products and Forest Industrial Development Research Program. Alberta also has an extensive forest genetics program, a joint effort of the AFS, industry and Alberta universities.

Scientific and Engineering Services. This division is responsible for overseeing a large volume of research and development, funded primarily through A/CERRF (see Section 2.1). Projects relate to furthering the development and use of energy resources, with emphasis on coal, renewables and energy conservation. Alberta's coal research capability has been greatly enhanced by the construction of a new research facility, built under the auspices of A/CERRF:

> Coal Research Centre, Devon. This new facility accommodates the research operation of the Alberta Research Council's Coal Program, the federal Coal Research Laboratory, and a private organization, the Coal Mining Research Centre. Thus, three centres of Western Canadian coal research are housed under one roof, facilitating interaction and coordination of effort.

3. THE FEDERAL GOVERNMENT

Over 60 federal departments and agencies either perform scientific activity or have the budgetary allocation to fund such activity. Following are descriptions of selected federal programs and facilities pertinent to Alberta.

3.1 Extramural Support

Several agencies of the Federal Government offer programs in support of scientific activity in the university and industrial sectors:

Natural Sciences and Engineering Research Council of Canada (NSERC). This federal granting agency is a principal funder of university research in the natural sciences and engineering. Support is offered in the form of research grants, manpower awards, development grants and research infrastructure support.

Social Sciences and Humanities Research Council of Canada (SSHRC). Supporting research in fields as diverse as archaeology, transportation and social history, SSHRC offers universities funding for research support, training and communication.

Medical Research Council of Canada (MRC). The MRC provides grants to help defray the costs of basic, applied, experimental, or clinical research; provides salary support to a limited number of investigators and research trainees in Canadian universities; and sponsors programs to help develop research in fields where major contributions may be expected.

National Research Council Canada

> Industrial Research Assistance Program (IRAP). Administered locally by the Alberta Research Council, this program is designed to enhance the commercial capabilities of companies by providing expertise and financial support to researchers in identifying industrial problems and opportunities.

Program for Industry/Laboratory Projects (PILP). Companies with sufficient technical and business capability to commercialize approved research project results are eligible for PILP support. The program involves the provision of access to science-based government and university laboratories and departments, and the technical assistance of their experts.

Department of Regional Industrial Expansion

Industrial and Regional Development Program (IRDP). This program provides support to projects at various stages of innovation and development.

Defence Industry Productivity Program (DIPP). DIPP is designed to enhance the technological competence of the defence industry in its export activities by providing assistance to industrial firms for selected projects.

3.2 Intramural Activities

The Federal Government's in-house research facilities in the Province include:

Agricultural Research Station, Lethbridge. The offices, laboratories and library of the Research Station form the major part of the complex known as the Agriculture Centre. The station employs scientists working in six disciplinary areas: soil science, plant science, crop entomology, plant pathology, animal science, and animal parasitology.

Institute of Sedimentary and Petroleum Geology (ISPG). Adjacent to the University of Calgary, the ISPG serves government, industry and the scientific community in the provision of geological information. The Institute studies the sedimentary basins of western and northern Canada, focusing on bedrock geology, paleontology, and the assessment of coal, oil and gas resources.

Northern Forest Research Centre. This centre, located in Edmonton, is responsible for fulfilling the federal role in forestry research, development

and technology transfer in Alberta, Saskatchewan, Manitoba and the Northwest Territories. Research areas include: environmental forestry; forest resources research (such as forest improvement and management); and forest protection.

Defence Research Establishment - Suffield (DRES). Located in Ralston, Alberta, DRES conducts basic and applied research on medical and chemical aspects of chemical defence, microbiology, chemical and biological defence training, military engineering and the disposal of hazardous and toxic materials.

Coal Research Laboratory (CRL). The Calgary CRL performs coal mining research primarily in the areas of underground ventilation and ground movement so as to improve health and safety in underground mining. The Edmonton CRL deals with research in coal cleaning and waste clean-up in order to upgrade product quality and to provide effective technologies to the coal industry.

4. THE PRIVATE SECTOR

Industrial research aimed at developing Alberta's natural resources has spawned an extensive support base of related industries, including firms involved in petrochemical, seismic, telecommunications, computer processing, laser and medical technology. The following section highlights some of these related industries, many of which have evolved technological applications in a broad range of research areas. The list is not intended to include all research performing units in the Province, but should be viewed as a representative survey of ongoing research activity in these emerging technologies.[1]

Global Thermoelectric Power Systems Ltd. is one of only three manufacturers of thermoelectric generators in the world. The company provides remote power systems which burn fossil fuels, converting them to electrical power. Advances are being made in liquid-fueled combustion techniques, ultra-sonic automization, new burner systems and thermoelectric converter designs.

Nortech Surveys (Canada) Inc. is a survey firm which specializes in positioning and navigation techniques. Nortech is involved in applied research and development of accurate marine and airborne navigation, and land static positioning and surveying, using satellite systems. The firm has developed a laser/inertial profiling system and is working on developing radio ranging systems for offshore, land-based and aircraft positioning.

INTERA Technologies Ltd. has adapted a Synthetic Aperture Radar System (SAR) for generating images mounted on small aircraft for commercial use. The system has found wide application in advising Arctic drilling and navigation projects of ice movement in northern waters. Through a project with the

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[1] Major petroleum recovery industries with research units in Alberta are not included in this summary. Although they account for the majority of industrial research and development expenditures in the Province, their activities are documented elsewhere. See Statistics Canada, Directory of Industrial Research and Development Facilities in Canada, 1985, Minister of Supply and Services Canada, 1985.

Alberta Research Council, a prototype of another INTERA concept - the Multi-Task Ice Data Analysis System (MIDAS) - will be built and tested in the field. MIDAS will process the data received from the SAR system.

Geotechnical Resources Ltd. offers advanced applied technology in engineering and geosciences. Geotech's capabilities include specialty tests and procedures in the areas of: routine and supplementary core analysis; research and engineering services; petrophysical studies; Arctic project management; and chemical analysis and laboratory equipment design, development and fabrication. Geotech's Engineering Division, the Arctic Group, provides cold room laboratory services as well as Arctic field services including monitoring, measurements, testing and construction related to both ice and permafrost.

Sherritt Gordon Mines Ltd. For over 30 years, Sherritt has operated a nickel and cobalt refinery at Fort Saskatchewan which has led to diverse metal fabricating facilities. Sherritt conducts extensive physical metallurgy research and development on new metal products. Much of Sherritt's research, development and engineering effort is a technical service to production plants to improve metal refining processes based on pressure hydrometallurgy.

Dow Chemical Canada conducts its research effort from its petrochemical complex at Fort Saskatchewan. In addition to process-type research, Dow is involved in areas of direct interest to the Alberta market, such as the development of agricultural herbicides.

Raylo Chemicals Ltd. A subsidiary of Terochem Laboratories Ltd. of Edmonton, Raylo researchers develop and manufacture high technology specialty chemicals and polymers. The company's contract research and manufacturing activities have included development of products for use in: oil, gas and coal recovery; synthetic DNA replication and other biotechnical applications; pharmaceutical trials; and in the rubber and agriculture industries.

NovAtel Communications Ltd. is involved in research, development, manufacturing and marketing of advanced cellular telecommunications systems and terminals. NovAtel manufactures the AURORA family of mobile radio

telephones. The company's cellular products utilize Very Large Scale Integration (VLSI) technology and the firm is developing custom integrated circuit designs utilizing Complementary Metal Oxide Semiconductor (CMOS) technology.

Digitech Ltd. Conducting research from its head office in Calgary, Digitech is involved in advanced digital processing of seismic data. Emphasis is on computer-assisted processing of geophysical and geological data of use to the resource industries. The company is currently involved in an innovative project which would transfer Digitech software into interactive graphic work stations that could be used by exploration geologists and geophysicists.

Teknica Resources Development Ltd. is a source of high technology seismic software and expertise. One of its most significant developments is a seismic inversion process which allows seismic imaging of the subsurface geological sequence to reveal rock type as well as rock shape. Product focus is on work station technologies encompassing artificial intelligence, high performance color graphics, and optical disk storage.

Idacom Electronics Ltd. focuses on data communications test equipment. Idacom's major product is their IDA-XP Protocol Analyzer which is designed to monitor, emulate and intercept or modify serial data.

EDO Canada Ltd. develops, manufactures and markets precision electronic instruments and systems for the land survey and marine positioning and navigation markets. The company is active in the design and manufacture of dual channel satellite doppler receivers and in the development of sophisticated software programs to process acquired transit data. EDO also has expertise in the development of integrated marine navigation and data acquisition systems for scientific research and seismic ships.

Caulfield Engineering This Edmonton-based firm developed the world's first stereo sidescan sonar system, the Acoustic Core, to measure ocean depth. It takes readings on either side of a vessel's path within a swath of 50 meters and has been used for construction of artificial drilling islands in the Arctic.

D.B. Robinson and Associates Ltd. This research-intensive group operates an experimental research laboratory, and is active in contract work in fluid properties and phase behaviour and in specialized computer software development for hauling oil and gas.

Myrias Research Corporation has designed and is building what may prove to be the fastest and most powerful supercomputer in the world. The Myrias 4000, a unit comprised of 4 096 Motorola 68000 microprocessors, will simultaneously perform a record number of functions. Myrias has also designed a high level programming language, Myrias Parallel Fortran, which is upwards compatible with Standard Fortran 77.

Keyword Office Technologies Ltd. This Calgary based company conducts research into the enhancement of existing office automation technologies. Keyword has developed KEYWORD 7000, a combination hardware/software system which integrates incompatible word processing systems through high-fidelity document conversion.

Westronic Systems Ltd. specializes in supervisory control and data acquisition (SCADA) systems. Emphasis is on development of remote control and data acquisition products for the oil and gas, telecommunications and power industries, particularly micro-computer based systems for energy management and control.

Wellsdale Research Ltd. specializes in the design and manufacture of microprocessor based data acquisition systems for telemetry and/or on-site computer readable data recording. Wellsdale designs, manufactures, and installs Arctic automated weather stations transmitting real time data via GOES (Geostationary Operational Environmental Satellite).

Harding Instruments Co. Ltd. is involved in the development of new products for the business telephone market. The company has begun North American marketing of a microprocessor-based, expandable two-line key system which overcomes long-standing American patents. Research is also being done on data transmission products.

General Systems Research Ltd. (GSR) Headquartered in Edmonton, GSR specializes in research, development and manufacturing of CAD/CAM laser cutting and engraving systems. With funding assistance from the Alberta Government, the company began a research and development program in 1983 that has resulted in the Laser CAM 400, a highly advanced computer-automated laser cutting technology. GSR also operates three laser and chemistry laboratories in cooperation with the Alberta Research Council and the University of Alberta.

Chembiomed Ltd. was formed by the University of Alberta in 1977. It has developed the technology to chemically produce blood purifiers and manufacture blood-typing reagents using cloned cells. Chembiomed is also working on commercial products based on a University of Alberta professor's discovery of a means to produce synthetic complex sugars, or polysaccharides.

Bio Logicals Inc. is currently involved in a joint venture genetic engineering project with the Alberta Research Council aimed at the development of pharmaceuticals and specialty chemicals. A computer program has been developed for DNA sequence analysis and researchers have been successful in incorporating and expressing, in yeast cells, the gene coding for the protein protamine.

5. THE UNIVERSITY SECTOR

Alberta's universities train skilled personnel and researchers in the humanities, social sciences, natural sciences and engineering, and work closely with industry and government on basic and applied problems in research and development.

The following description focuses on the activities of selected faculties who may report receipts of research funds from outside agencies: it should be borne in mind, however, that sponsored research constitutes only a portion of on campus research and scholarship. Numerous studies requiring only the institution's existing resources and the investigator's scholarly reflection are conducted in virtually every university department.

University of Alberta. The University of Alberta maintains a commitment to respond to changing research needs and new research directions, provincially, nationally and internationally. Most recently the University has embarked on an expanded program of technology transfer, moving the ideas and products of the university into industry and government in new ways for further research, development and commercialization where appropriate.

Medicine. Medicine is a major focus of research at the University. The Protein Group in biochemistry is active in the study of various aspects of protein and enzyme structure and function and in the application of this knowledge. This group receives the largest operating grant ever awarded by the Medical Research Council of Canada. Work with industry is being pursued; for example, the Alberta Peptide Institute provides custom peptide synthesis for research centres and commercial firms in Canada. The Alberta Heritage Foundation for Medical Research is now furthering this work.

A variety of research in monoclonal antibodies for diagnosis in cancer is moving toward commercialization. The University is

active in the development of artificial prostheses and of new techniques in nuclear magnetic resonance applied to diagnosis of disease. New drugs are in various stages of research in Medicine and Pharmacy.

Engineering and Related Areas. Initiatives in the field of engineering include: the acquisition of the Mechanical Engineering Acoustics and Noise Unit (MEANU), a building materials testing and research laboratory located in Edmonton; dramatic growth of the Alberta Microelectronic Centre with new fabrication and design facilities in Edmonton and Calgary respectively; and the Alberta Laser Institute, structured to utilize the University's resident expertise in laser technology to exploit opportunities jointly with industry in areas such as laser material processing. The Natural Sciences and Engineering Research Council provides financial support to leading scholars in a number of disciplines in the form of operating and equipment grants, among other types of assistance.

Humanities and Social Sciences. A major project entitled "The Collected Writings of Louis Riel" was completed in 1985 after some five years of intensive effort in the humanities. This five volume publication contributes significantly to our understanding of the experiences of native peoples in Western Canada. Funding support was received from a number of sources including the Social Sciences and Humanities Research Council. In the area of social science, the Population Research Laboratory continued to undertake a number of surveys of academic and popular importance, including the Edmonton Area Studies.

Northern Commitment. The University is alert to its geographic location in North America and its obligations to Alberta and the North by virtue of its northern location. The Centre for Frontier Engineering Research (C-FER) and the continuing work of the Boreal Institute for Northern Studies represent efforts in this direction.

International Focus. The university is responsive to the growing international dimension of the knowledge business, to the movement for international involvement of Canadian organizations and to the increasing importance of Pacific Rim countries. Research programs are undertaken with this international dimension in focus. The Faculty of Agriculture has a major CIDA sponsored agreement in China in this respect and a number of IDRC projects are in motion involving China, Costa Rica and Argentina.

New Directions. The growth of industries based on knowledge and information systems, such as computer, biotechnology and communications firms has changed the position of universities. The University of Alberta is actively involved with companies in these fields and in addition has created a fully owned company of its own in biotechnology, Chembiomed Ltd.

University of Calgary. The University of Calgary's research funds from outside agencies have more than doubled in the past five years and the average external support per full-time faculty member is now over $34 000. Accordingly, an effort has been made to strengthen university/industry links, through the establishment of an office of technology transfer to facilitate the commercialization of technology and products developed on campus.

Medical Research. Medical researchers attract almost 50 percent of the University's external research funds. Recent studies include research into such diverse areas as the nature of sleep apnea, occupational lung diseases, the healing process of ligaments, and the structure, functions and dynamics of various blood components. Concern for the ethics of experimentation has led to the establishment of a Medical Research Ethics Program encompassing both active research and a special Ethics Review Committee.

Computing Technologies. University of Calgary researchers are keeping pace with the needs and interests of Alberta industry and government for high technology solutions. The Cyber 205 supercomputer, acquired in 1985, has demonstrated its value in research not only within the university community, but also within government and industry.

Maintaining a close liaison with industry, the Software Research and Development Group conducts research in artificial intelligence, VLSI design, distributed computing, graphics, human-computer interfaces, dynamic documentation, and database design.

Crossing traditional disciplinary boundaries, sponsored projects in computer applications research range from satellite images and seismic processing technologies, to CAD/CAM assisted artificial limb design systems and algorithms, to process computer tomography images of the brain.

The Canadian Centre for Learning Systems (CCLS), a non-profit organization involving Calgary's five educational institutions, and three partners from the private sector, provides a focus for the development of computer assisted learning projects.

Biotechnology. A 150 litre microprocessor controlled fermentation facility in the faculties of Medicine and Engineering supports an emerging biotechnology program at the University of Calgary. Biotechnology research includes bio-reactor production of pharmaceuticals, micropropagation of trees, plant hormone applications and gene transfer.

Environment. A large scale biophysical research contract was awarded to the University of Calgary in 1985 by the Province, the petroleum industry, Alberta's electrical utilities, the Energy Resources Conservation Board and the citizens of Alberta. Led by the Kananaskis Centre for Environmental

Research, this major project of the Alberta Acid Deposition Research Program involves scientists from the departments of Biology, Physics, Mathematics and Statistics as well as a number of geoscience and environmental companies and laboratories.

Energy Research. Basic and applied research ranges from projects on in-situ combustion and the desulfurization of coke from oil sands processing plants to studies of mineralogical changes during steam treatment and their effects on reservoir properties and recovery efficiency.

University of Lethbridge. Providing post-secondary education to Albertans at the undergraduate level, the University of Lethbridge maintains a significant research budget. Research at the University includes: individual projects on the environmental effects of oil sands plants; development processes in poplar and maize; animal parasites in water systems; aspects of neuropsychology; perceptual problems in infants; paleomagnetic studies of glacial sediments; and studies of atmospheric emission spectra.

Athabasca University[1]. Athabasca University, located 150 kilometers north of Edmonton, is one of two Canadian universities devoted solely to the delivery of university-level courses by distance education methods. Individual research at the University deals not only with discipline-related fields, but also with the development of distance education methods and technologies, particularly computer assisted learning and computer managed instruction.

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[1] Note that Athabasca University's research expenditures are not included in the statistical portions of this report. The methodology employed to estimate university research expenditures requires that institutions show annual sponsored research receipts of greater than $1 million.